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ABSTRACT

This manual is a collection of analects from seven university manuals for indoctrinating graduate assistants in the teaching of undergraduate mathematics courses. Topics and exercises deal with class conduct, record keeping, chalkboard techniques, homework, test construction, question strategies, attitude, and Polya's ten commandments. Included are fifty-one selected references classified according to method, learning environment, content, problem-solving, teaching and research, and careers in mathematics. (Author/RN)

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A Compendium: Manual for Graduate Teaching Assistants in Mathematics

Edited by

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Analects from manuals by graduate assistants:
Dickey and Hunter, University of Wisconsin, Madison, 1966
Finkelstein and Stone, University of Colorado, Boulder, 1969
Others - Purdue University, 1967
Berkeley, 1968
Rutgers, 19??
University of Arizona, 19??
Bowling Green State University, 1972

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"Where shall I begin, please your Majesty?" he asked.
"Begin at the beginning," the King said, very gravely,
"and go on till you come to the end: then stop."
Lewis Carroll, *Alice in Wonderland.*

GOOD BEGINNINGS

1. At the first class meeting and for the next three or four class meetings, write your name and office hours on the board. Some students don't know their instructor's name even at the end of the course.

2. As early in the course as possible, preferably during the first week, you should decide on and explain your grading system. Tell the students what is expected of them. (For example, don't wait until the end of the semester to decide to count homework on the final grades.) Also set up definite office hours, and make yourself available by appointment.

3. Some teachers use the first class period to tell students about applications of the material they will be studying. It should be explained that the material you and they will be learning is worthwhile, although some applications cannot be fully understood until the last weeks of the course. In such ways students (especially engineering majors) can be prevented from giving up "because mathematics is too abstract". Your faculty mentor may be helpful here to explain the scope and depth of the course. You might also give a broad outline of your course. Tell the students approximately when the exams will occur.

4. Spend some time looking over the entire text and syllabus for your course. Familiarize yourself with the scope of the course. Prepare written class notes, but don't copy the text onto the board. Don't try to lecture off the top of your head; have at least an outline of what you wish to cover. Reread your notes or outline just prior to class time to avoid false starts. Whenever you get on a wrong track and have to ask your students to ignore something you said, they tend to overdo it.

5. Students are impressed by a teaching assistant who gets to know them quickly. You should take roll at least until you know them all. Returning assignments to individual students at the beginning of each class period, although time consuming, is one way of giving students some personal attention. During the first day of class, when roll call is taken, you may wish to note where each student is seated. At the next class meeting most of the students will be in approximately the same location.

6. Students often show an initial burst of enthusiasm. The first two weeks may best be used to dive deeply and quickly into a topic (1) which is new to most of them, (2) which seems useful to them, and (3) which uses a new skill (or new skills). The initial material is usually learned well, so a topic that will frequently reappear through the course should be taught first. It is an unfortunate practice to teach conic sections at the beginning of a second-semester calculus course.

7. Most teachers seem to feel that beginnings must be slow. If the initial work is too slow, there will not be adequate time for the more difficult material at the end of the course. Rapid beginnings will accustom the student to giving a relatively great amount of his time to your course (most of his other courses will begin at a slow leisurely pace). If enough difficult material is covered in the first few weeks, the first exam can actually indicate how well the student is doing (so that the poor students will be able to drop to a lower level course).

If you can't communicate, the least you can do is sit down and shut up.
--Tom Lehrer.

ESSENTIAL BLACKBOARD TECHNIQUE

1. It is most important that you begin writing at the top of one blackboard panel, move down that panel, and then proceed to the next panel. You should not skip around the blackboard, placing equations haphazardly here and there.

2. If you are right-handed, you should begin at the rightmost front panel and proceed leftward. In this way it becomes unnecessary to stand in front of a panel already filled (from which some students may still be taking notes) while a new panel is being written on. A gymnastic alternative is to face the class while writing.

3. If you have more than two rows of students in the class, do not write all the way to the bottom of the board because those in the back will not be able to see. Keep the desk at the front of the class clear of any large objects such as a lecturn or a briefcase.

4. Face your class as much as possible. Maintain eye contact with your students. Don't stand in one place for the entire class period; move around the room. Speak while you are writing on the board.

5. You should try to put complete statements on the board, not just a few symbols. Your students' notes usually will consist of what you have put on the blackboard. If a student doesn't understand some point presented in class, he should be able to turn to his class notes and recover the missing information. Some teachers use an eraser to simplify a complicated mathematical expression. This technique is guaranteed to annoy students taking notes.

6. When you are solving a problem at the blackboard, you should put up a complete statement of the problem or indicate where it can be found in the text. Define in writing on the board any variables used in the solutions. Work the problem to completion so that your students will learn to recognize a solution.

7. Important results that you want your students to memorize may be emphasized by squaring them in chalk. An example would be the equations for the derivatives of the trigonometric functions. A word of caution: do not make your course a memory course. Emphasize the importance of thinking a problem through from first principles or known results.

8. In using the triple-layer blackboards in the large lecture halls, use the middle-layer board, sandwiched between the front and back layers first. When done, push it up and pull the front board down, so that what was just written is still in sight. After using the front board, push it up, and use the back board (the front board will still be visible). Then move to the next triple-layer panel. One may wish to prove the proposition: There is no suitable technique for using all n layers of an n-layer blackboard if $n > 3$.

From desire ariseth the thought of some means we have seen produce the like of that which we aim at; and from the thought of that, the thought of means to that mean; and so continually, till we come to some beginning within our own power. -- Thomas Hobbes: *Leviathan.*

THE TEACHER OF MATHEMATICS

All of the preceding is applicable to teaching in general, but there are specific features of mathematics which make the teaching of mathematics different from the teaching of other subjects.

1. The first of these is commonly phrased as, "Mathematics is not a spectator sport". It is simply impossible to learn mathematics by doing nothing more than reading and listening to lectures; the teacher of mathematics must be more concerned than almost any other teacher with getting his students involved in doing actively rather than listening passively.

2. A second feature is the nature of mathematics as a science - it is neither empirical nor irrelevant to real phenomena. But where, then, does it stand in relation to reality? Mathematics is in large part a three stage development consisting of (1) the abstraction from real phenomena of certain salient features, (2) the creation of an "otherworldly" theory embodying those features, and (3) the application (where it fits) of the theory to real phenomena. It is apparent that concentration on the second stage to the exclusion of the others distorts mathematics and leads to students' lack of understanding of both the specific subject matter and the nature of mathematics itself. There is no justification for giving students the impression that mathematics is incomprehensible or a mystery akin to black magic.

3. A third important feature is the axiom-definition-theorem-proof structure of mathematics. The teacher of mathematics must ask himself, particularly in relation to elementary classes, what is the best way to achieve his goals for that class. If the class does not consist of future professional mathematicians, then the usefulness of proving every stated result is clearly questionable. This is not to say that proofs should be omitted, for every class in mathematics should contribute to a student's understanding of the nature of mathematics and proofs of theorems are most definitely a part of that. However, the goal in most cases is the student's understanding of the result and his ability to use it correctly; the question must be raised - to what extent does the rigorous proof contribute to the teacher's goals for the class?

TEACHING ROUTINE SKILLS

In any math course there are a number of routine problems which the student should learn to carry out. For example in an algebra course this might include solving quadratic equations; in calculus, differentiating polynomials; in matrix theory, finding the rank of a matrix, and so forth. Even if you prove that these techniques work, you should precisely and clearly state the algorithm and illustrate its use with several examples. Homework problems testing the student's

ability to perform a new routine skill should always be given. Even the poorest student should learn to solve routine problems in a routine way — even if he doesn't understand why the technique works(this will give him the satisfaction of being able to do something in the course). You should personally make sure that everyone in the course learns to do the routine problems. The ability to perform routine manipulations sometimes gives a hopelessly lost student such a feeling of accomplishment that he may even try to catch up in the course.

Exercise. List the routine skills which all your students — even those who fail the course — will be able to carry out when the course is completed.

TEACHING ROUTINE FACTS

It may be worthwhile to give a brief pre-announced quiz at the end of each week asking the students to reproduce the important pieces of mathematical knowledge that you have given them during the week. Even the poorest students will thus learn some important basic facts which you have proved in class. Such quizzes are not necessarily a grading tool, but a teaching tool. Through them you can be sure that your students have a certain minimal knowledge (eg. the integrals of some frequently encountered functions).

Exercise. List the routine facts which all your students — even those who fail the course — will know when the course is completed.

TEACHING KEY CONCEPTS

In every course there is a certain small number of ideas and concepts upon which the course is based. Your students will have a very hard time determining these concepts, since for them each page of their text is as mystifying as the previous page. Part of your job is to emphasize the key ideas. At the end of the course when you review the material, stress the key concepts of the course. The faculty coordinator may be helpful in this area.

TEACHING OUTSIDE CLASS

There are regularly scheduled help-sessions manned by some of your fellow TA's. Check with the office for the schedule. For the die-hards in your class, hold your own — I'm from Missouri — helpsessions. But, the meetings of the Missouri Club should be no latter than two days before the exam (ie. before it's to late.).

If you have any books, programmed texts, notes, old exams, old homework, or other material of a supplementary nature that you want to make available to your students, it's possible to put the material on reserve at the Reserve Reading Room in the Main Library.

ASSIGNMENTS

Some TA's give no assignments at all on the assumption that students will work on their own and ask questions about those things that they do not understand. Such a TA has probably forgotten his own undergraduate career. He is baffled when his students do not ask questions. What he does not realize is that most students do not recognize their lack of understanding or inability to work a problem until they attempt to work the problem. One approach is to give short assignments daily, due the next class meeting, and to be returned by you on the day of the next class meeting after that. This method has certain advantages:

1. You remain aware of how your students are doing.

2. Short assignments can be corrected more quickly.

3. Almost immediate reinforcement is provided for the student's efforts, so that he knows quickly how well he is doing, before interest is lost.

4. The assignments are not so long that they discourage students from studying the course material.

5. The student becomes accustomed to systematic regular study for the course, so that he won't wait until the day before the exam to begin studying.

6. When assignments are given to students, they gain the satisfaction of being able to do something for the course.

7. Returning assignments to your students helps you to learn their names.

8. When students receive definite assignments, they gain some idea of what sorts of problems they are expected to learn to solve in the course.

9. The student has a set of solved problems to review for the exam.

Another alternative is to give weekly assignments. Prepare and distribute a dittoed assignment sheet. The student can keep track of those problems he has completed and those he is having trouble with. Some students prefer to study for a given course in a large unit of time rather than one hour each day. These assignment sheets allow them to choose their own pace.

Regardless of when you give assignments, you should realize that homework must be given. Mathematics is done with pencil and paper (lots of it), not just by reading. Make the assignments of reasonable length and carefully look over what you collect. If your marking is sloppy and incorrect, the student will cease to hand in homework. If you mark a problem incorrect, point out what the mistake is.

Aimlessness is the most important single cause of ineffective teaching -- AAUP

SOME TECHNIQUES

Remember when you took the course you are now teaching and some of the problems you had? Your present mathematical background is much different from the time when you took such a course.

1. Try to begin each classwith a five-minute discussion of ideas with which the students already feel comfortable, rather than plunging into new material. You may wish to review the topics you have been covering and at the same time point out the goals toward which you are aiming. In this way the students can be led in a continuous fashion to the more difficult material of the course. Also, students entering the class late have a chance to figure out what is going on. By association of the new matheial with the old, the student begins to have solid contact with the new material; it seems real and stable. When presenting a new theorem, explain how it fits into the general theory of the course. A common complaint among students is that they understand this or that piece of information, but they are just not sure what it means. Just what is, the 'Big Picture'?

2. A very useful teaching technique is to ask frequent questions of individual students. This has many advantages. When introducing new material it can stimulate the student's intuition. When reviewing or using material already covered, it can make the student aware of what he should know. It also gives the teacher the opportunity to rework a concept if the student is not sure of the answer. Time spent in this way is seldom wasted since there will probably be others with the same problem and it lets the students know what material you think is important. Another advantage is that it keeps students awake. Call on <u>all</u> students. If you call on just the bright ones, you will discourage the poor ones. If you call on just the slow ones, you will give a false sense of security to the average students.

3. Try to develop yourself as a moderator with the students reciting. Don't talk all the time and don't be in a hurry to supply answers to questions you have posed. A little silence won't hurt the class and will give students time to think. If you talk for more than half the class period, you are talking too much.

4. At the start of the course be very detailed in your use of high school algebra techniques to refresh your student's memories. For students in the more advanced courses you should explain in some detail the principles of calculus which you are using. You may wish to reference theorems and concepts to pages in their text or to previous texts they have used. Above all, your presentation should be clear and continuous. If you're trying to give a rigorous proof, be sure each step and it's relation to the previous ones is clear. If you're trying to give an intuitive motivation of something, point out how the intuitive notion is related to what is to be motivated. Review and restate things often. At the end of a long or complicated problem or proof, quickly run over the main steps again (or ask a student to).

Ignorance and stupidity are not the same, but confusion of the two is. --Mensroom Wall, 3rd floor library.

EXAMINATIONS

1. Many teachers use "blue books" for examinations. The advantage is that there are no crib marks on the paper before the exam. A better alternative is to ditto examinations with appropriately spaced questions on the page so that there is enough room for working the problem on the test paper. This will aid you in grading because you will not have to flip through many pages hunting for solutions. If you are teaching in a large lecture-recitation course, have a place for each student to put his name and his discussion leader's name on each page. The exams can then be separated so that each assistant can grade one problem on every test paper. (If you are unlucky enough to get a student with large fourth grade handwriting, you can always supply him with extra paper.) Alternatively, grading such a large number of exams can be done together. The lecturer and TA's can grade particular questions and then pass the papers around. Separating the pages of a students exam can ofter lead to confusion.

2. After the first examination suggest that those students who have made D's or F's come to your office for individual consultation. (Most of them will want to talk to you anyway.) Tell them that they are not doing as well as their classmates. Find out why. Explain that competition is rougher in college. Most students will respond very favorably if they know that you want them to do better. If it is clear that the student is not prepared for the course, now is the time to advise him to drop back to a lower level. In most cases this is better than wasting his time in a course he will not be able to pass. Ideally this situation should not arise. Such a student should have been identified in the first two or three weeks by his performance on homework. This early identification gives the unprepared student a second chance in a lower level course. Have at least two major exam grades on which to base the students mid-term grade.

3. Make it difficult for students to cheat on an examination. Spread them out using only every other row or seat if possible. You may obtain a larger class room for exams by checking with the department secretaries well in advance. If another TA teaches the same course, and your exams will be given at about the same time; you might make up alternate exams together. You can number all test papers and hand them out in some order, thus easily checking similar exam papers against the seating arrangement. Or you might write your students names,in pen, on their exams; thus insuring that alternate exams are not exchanged. Check your seating chart, and mark those absent; thus insuring that those who took the exam handed it in. With the advent of large classes a student should not be offended if you check the isomorphism of: student; student's I.D.; student's exam. Have the students clear their desks. You should remain in the classroom during the exam.

4. If you suspect cheating on an examination, you should discuss the matter with your faculty mentor. This goes for both recitation instructors and TA's with their own course. This is a very serious

matter and the University has a definite policy on such matters. Let someone with more authority assist you. In addition you could possibly

a. Have the students involved come to your office.
b. State clearly that you are not accusing them of cheating.
c. Have them observe the unusual similarity of their papers.
d. Inform them that you are keeping their exams on file to become "Exhibit A" if further evidence is found.
e. Separate suspects at the next exam, so that you can keep an eye on them.

5. Try to eliminate time as a factor in exams. A student may know the material but may not write or think as fast as others. If there is no conflict among your students you could begin earlier or extend the exam period. Night exams with no time limit is another possibility, but only if the entire class consents. Of course the exam you give should not be lengthened from a normal class period test. Curiously, many students bring electric calculators or slide-rules (as time savers) to exams nowadays: you should state your policy, in class, way before the exam, with regard to such.

6. Don't disturb your students with a verbal count down during the exam. Tell them when their time is half up and then when five of so minutes are left, even if there is a clock in the room. Also if you observe a student is falling asleep or is stuck on a problem, announce that they should be on problem so-and-so or page so-and-so at this time.

7. The following grading proceedures often prove useful:
   a. Place the student's name on the exam paper away from the problems so that the grading is objective.
   b. Grade one problem at a time. This may take more of your time, but the grading will be more uniform.
   c. Grade your exams immediately. Hand back and discuss at the next class meeting, if possible.
   d. List the grade ranges and the median grade or list all grades on the board.

ADVANTAGES AND DISADVANTAGES OF OBJECTIVE TESTS

Objective tests have several advantages to recommend their use in college teaching. First, because they are brief and require only a minimum of writing by the student, a considerable number of objective items may be included in a single test. Course content and course objectives may thus be sampled widely. This, in turn, improves the fairness of the test to a student who may be completely blank on a single narrow aspect of the work. Another advantage of objective tests is that they can be made quite reliable. With modest effort, items can be written so as to reduce inconsistencies of scoring by persons having different opinions about "correct" answers or other qualities of responses. A third advantage of objective tests which appeals to instructors of large classes is that they permit accurate scoring, with a key, by clerical

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The sections on test construction are taken from: College Teaching - A Systematic Approach, by J.W. Brown and J.W. Thornton

personnel or machines. The time required for this task is usually less than for essay tests.

Several apparent disadvantages of objective tests should also be mentioned. One is that a good objective test requires a considerable amount of time to prepare. But the time saved through simplified scoring procedures and the opportunity to reuse good items in future tests aid in counteracting this disadvantage. Two other alleged disadvantages are still being debated: that objective tests encourage poor study habits through emphasizing unimportant details and that, because answers are usually checked rather than formulated in the student's own words, they hamper the improvement of writing ability.

SUGGESTIONS FOR PREPARING OBJECTIVE TESTS

Prepare tests of sufficient length to provide reliable results. As a check against omitting items measuring important objectives or content, prepare a two-dimensional grid. Put course topics in a list down the left-hand side; arrange course objectives in columns across the top. Check and insert item numbers in appropriate columns as they are completed. Note and correct gaps which develop.

Choose a variety of test items for the special contributions each can make to the measurements sought.

Seek to measure one improtant thing with each separately scored item. Avoid using the answer to one question as a key part of a following item.

Write items in a straight forward manner, avoiding tricky phrasing, double negatives, unfamiliar words, ambiguities, or unnecessary verbiage. Be as brief as possible without sacrificing meaning. A test should be a measure, not a puzzle. Avoid quoting from the text.

Avoid too many easy items which can be answered correctly by everyone in the class.

Randomize correct responses so that students do not detect some system which may have been employed to facilitate scoring.

Ask a colleague to read items to check clarity and to see how a person familiar with the material responds to them. Revise and simplify wording or format, as suggested.

Assemble items of one type in the same test section; do not intermix. Precede each section with a part number and a set of directions. If necessary, include sample questions to guide response patterns.

TRUE-FALSE ITEMS

True-false test items, usually consisting of single statements to be marked "true" or "false," have been criticized for several important reasons. Since there is a fifty-fifty chance of one's being able to answer such questions whether or not he knows anything about them, the form encourages guessing. Too, undeniably true or false items are difficult to construct: there are so many qualifications to influence answers. Finally, the true-false format tempts some instructors to prepare items through the simple process of altering textbook statements, thus encouraging in students the wrong kinds of learning and the wrong kinds of preparation for tests.

But true-false items do have the special advantage of permitting the instructor to sample widely from among course elements. They are also sufficiently brief to permit economical duplication in test-sheet form, and they are easily scored. If constructed with care they have certain limited contributions to make in measuring achievement in college classes, especially ability to recall essential facts.

Following are several general suggestions for developing true-false tests:

1) Use as least forty to fifty items in a quiz and one hundred items in a regular examination: shorter tests reduce reliability.

2) A combination of two or more types of questions is preferable to a test composed solely of true-false items.

3) Divide true and false items in about equal proportions and distribute in random fashion throughout the test.

4) Avoid using such words as "all," "only," "most," "frequently," "never," "generally," "always,"

5) Simplify statements as much as possible; avoid double negatives or unnecessarily involved sentences.

6) Avoid trivia; develop items which require students to think with what they have learned rather than simply to recall it.

7) Avoid making true items consistently longer or shorter than false items.

Several variations of simple true-false items are sometimes used. With one type, the item may be written so that all but the stem is underlined. The student is asked to react to the complete statement as it stands; if he considers it false, he must rewrite the underlined portion so as to make it true. Another type checks thinking ability by first presenting a statement which students rate as true or false and then asking them to check related statements which support their choice. Sometimes a main stem statement is given and followed by several statements to complete it. Students are asked to rate each completion statement as true or false. Another variation is to ask students to check items as "true", "probably true", "probably false", or "false".

MULTIPLE-CHOICE ITEMS

A multiple-choice item usually consists of a statement or question accompanied by several choices or answers-of which only one is correct, or "best." The multiple-choice form has several advantages over the true-false form just discussed. It is generally regarded as a useful means of measuring certain higher level mental functions (critical thinking, comparison, judgment) which are difficult or impossible to measure with true-false questions; it lowers chances of success through mere guessing; and it permits the presentation of test situations in the more lifelike circumstances of "choices to be made."

Following are several general suggestions for developing improved multiple-choice items:

Generally speaking, provide with each item only one correct or best answer. (See additional comments below concerning a variation of this procedure.)

Write four or five alternative responses for each item; try to make each response plausible.

Test one main (and important) idea or course aspect with each item.

Relate ideas for the stem and responses within items; avoid a spread of ideas within the same item.

Pack as much of the item as possible into the stem; make responses brief and clear and of approximately equal length.

Make sure that statements proceed grammatically from the end of the stem to the end of each response.

Strive for clear expression; avoid confusion caused by unnecessary length, ambiguity, or tricky or abstruse language.

Underline words like not or all except to avoid their being overlooked.

Avoid making correct responses brief and clear and incorrect ones long and involved.

Do not reveal answers by the use of "a" or "an" at the end of the stem.

Scatter correct responses in random order.

Avoid questions which can be answered on the basis of general knowledge rather than on what has been learned in the course.

Use novel data in items which require thinking and application of principles rather than recall of information exclusively; avoid items which are verbatim from the text.

List response choices in columns, rather than in paragraph form; for ease of scoring, provide a uniformly placed space with each item in which to record answers (or use a standard answer sheet).

Several variations of the above procedures may be used to provide functional measurements of some instructional outcomes which cannot be presented adequately

in problem form through usual verbal means:

Use visual materials as part of the standarized presentation of item stems or response choices. For example, prepare a large transparency containing several pictures or drawings, of which one is the best answer to a problem. Several smaller 2- by 2-inch slides may also be laid on the projection surface to provide materials for the items.

Base several written questions on a projected still picture or a portion of an unfamiliar motion picture (perhaps one projected silently, with sound turned off).

As part of the problem material for a test, give a demonstration accompanied by a carefully prepared oral commentary explaining or commenting upon tasks performed. Prepare written questions which measure the ability of students to judge the accuracy, correctness of order, or validity of explanations accompanying the demonstration.

Use prepared tape or disk recordings of quoted or dramatized materials on which to base questions. Specially selected (original or quoted) written statements may also be used similarly.

Include reproductions of drawings, graphs, or photographs in items within tests given to students.

MATCHING ITEMS

Matching items are generally composed of two related lists of words, phrases, symbols, or pictures. The task is to match each item in the first list with the most closely related or appropriate item in the second. Matching items are particularly helpful in measuring the ability of students to relate principles to situations in which those principles operate, to select correct definitions of terms, or to tie causes to effects.

Following are several general suggestions for the improved preparation of matching items:

1) Make the alternative answer list longer than the problem list (unless directions specifically indicate that each alternative may be used more than once).

2) Make problems and responses in each matching questions deal with one subject.

3) Use at least five but no more than twelve problems in each item.

4) Make items brief without sacrificing meaning.

5) Avoid splitting matching items on parts of two pages.

6) Arrange possible problems and answers in some readily discernible manner (alphabetically, chronologically, logically).

COMPLETION AND SHORT-ANSWER ITEMS

Completion and short-answer questions require the respondent to fill in blanks with one or more words or phrases which he himself has recalled or developed to complete the thought or to answer the question. The blanks themselves may be within emasculated sentences (_____ followed Churchill as British Prime Minister after the fall of Germany in World War II); or they may be sirgle words, phrases, or numbers in answers to direct questions (What is the latest estimate of the population of the United States? _____).

Completion and short-answer questions cannot be scored so objectively as some other types of questions discussed in this section. Consequently, their scoring usually cannot be handled by one unfamiliar with the nature of various acceptable answers. However, both types of questions are particularly useful in measuring ability to recall specifics, such as names of individuals, dates of events, place names, titles or authors of books, ability to solve mathematical problems (leaving space for inserting correct answers), and for similar purposes. Suggestions for improving completion and short-answer questions follow:

1) Avoid indefinite completion items which an be answered correctly in several different ways. Structure each item so that the correct answer is clear to the person who really knows it.

2) Avoid giveaway articles (a, an), as well as singular and plural antecedents, which may provide clues to answers.

3) Restrict blanks to key words and do not omit so many that sentences resemble puzzles. Do not omit sentence verbs (as in "Marat ____ the _____ of _____ in _____.").

4) For ease of scoring, require answers to be written or marked uniformly along the margin of the test page or on a separate answer sheet.

ESSAY TESTS

Essay tests are highly regarded by most college instructors for whose courses they are appropriate and by some for whom they are not. They are believed by many professors to be capable of measuring the "higher mental processes" - summarizing; presenting arguments for or against; evaluating rationality and suitability of conclusion, or proposed or actual courses of action, writing creatively; and similar intellectual tasks.

However, experienced instructors are also aware of the disadvantages of essay tests. While they are relatively easy to prepare, they require considerably more time than objective tests to read and score. Since the student presents responses in his own words, with his own style, organization, and spelling, they are often unstructured and unstandardized. It is difficult to judge correctness or quality with any reliable degree of objectivity. Sampling of student knowledge can be deep and detailed in areas covered by questions; but both the limited number of questions which can be asked in essay tests and the difficulty of achieving objectivity in scoring reduce the reliability of results. The essay test may require the student to recall, interpret, or analyze rather than to identify a correct, ready-prepared alternative response as in a multiple-choice item. The instructor, therefore, frequently experiences difficulty in separating poor spelling, poor handwriting, or poor style or organization from the student's real ability with respect to the subject of the question.

IMPROVING RELIABILITY OF ESSAY TESTS

A common criticism of essay tests is that they are unreliable. Their reliability may be improved, however, by delimiting and structuring the items as discussed above and by carrying out procedures such as the following:

Determine, first, whether an absolute or relative scale of scoring will be used. When operating from the absolute frame of reference, the instructor determines arbitrarily the standards to be used in assignming a certain grade or score without regard to a curve of performance for the class as a whole. If the relative scale is used, however, the following procedures will apply.

Read the same question in all papers, seriatim, rather than one complete paper at a time. This procedure, and that of concealing student names, helps to reduce the halo effect (the carry-over of judgment from one question to another on the same paper, or from knowledge about the student, to his performance on the test as a whole). Too, it provides better bases from making comparisons of answers.

Apply predetermined criteria for judging the quality of student responses. An itemized checklist may be used as a reminder of facts, principles, generalizations, conclusions, evidence, or sources of authority. Instructors sometimes make check marks on papers to indicate the presence of expected elements and then use the total of such marks as the basis for a grade on the question.

For each answer read, sort papers into several piles (from five to nine are recommended). Make the judgment that "this paper is better than that one, poorer than this one." Move papers into different piles as further comparisons are made.

It is generally agreed that the practice of permitting students the option of selecting essay questions they will answer in the test (such as "Answer three of the following five questions.") reduces the value of comparisons of student performance on the test as a whole, since the students, in effect, are taking different tests.

DEVELOPING SATISFACTORY ESSAY QUESTIONS

The special difficulties which instructors encounter with essay questions suggest three procedures which will improve their quality and usefulness, as follows:

Essay questions should capitalize upon their unique advantages. Questions are recommended which require students to "tell why," "criticize," "contrast," "summarize," "compare," "explain why," "trace the development of," "give examples," or "evaluate." Questions asking students to name individuals, give dates, assign titles, define terms, make lists, or enumerate usually may be presented more effectively in objective form.

Essay questions should be stated unambigously. Good essay test items should convey to the student the meanings intended by the instructor who wrote them. Ambiguity can be reduced by economical use of language, by careful attention to the framing of questions, by thinking of likely responses of students to the wording employed, by trying out questions with one's colleagues or students before they are used in class, and by revising items, after use which experience shows are faulty.

Essay questions should call for structured responses of somewhat limited scope. A common fault of essay questions is that they are too broad in scope. Obviously, the broader the range of acceptable response to essay questions, the more difficult it is to compare one student's response with another and the less reliable its scoring is likely to be. One means of ameliorating (if not eliminating) this problem is to indicate in the question itself the scope of the expected answer. This may be aided by avoiding use of vague words such as "describe," "discuss," or "tell about," without further restrictive words or phrases.

The so-called open-book essay examination lends itself to evaluation of the student's ability to find, assess, and use information rather than simply to recall or restate it. To many, it represents a superior means of determining the degree to which a student knows sources of information and how to use them rather than simply to recall facts which may or may not be appropriate to the purpose. Good questions for the open-book essay test require the student to integrate, interpret, synthesize, or generalize-not to quote verbatim responses from books he consults. The open-book examination is sometimes given in the library itself, with a set time period allotted for completion of assignments and full freedom to use all resources in the building.

... naturalists observe a flea
Has smaller fleas that on him prey
And these have smaller still to bite 'em
And so proceed ad infinitum.
-- Jonathan Swift, *On Poetry.*

THE LECTURE-RECITATION COURSE

A lecture-recitation course is a course with divided teaching responsibility. It has a lecturer who meets with the entire class (from 100 to 200 students) several days a week and a number of assistants who meet with small sections of the class (of 20 to 30 students each) at the other times.

You will meet very early in the course--maybe even before the first lecture--with the lecturer to decide on important course policies such as the number of exams to be given, the assignment of homework (i.e. whether the lecturer will assign all problems), and emphasis of the exams (such as mostly theory or mostly problems, etc.). Your lecturer will provide you with a syllabus for the course so that you will be able to adjust your pace in discussion sections to stay abreast of the lectures. Don't get ahead of the lecturer.

Your lecturer will want to be informed about the problems your students encounter in the lecture. You are often the person best qualified to pass on this information. Your lecturer may want to visit your discussion section and will probably let you know in advance. At least one lecturer has been known to give assistants a vacation by taking their sections one at a time so that he can get direct student feedback that is impossible in a large lecture.

you will probably work with the lecturer in making up the examinations for the course and he will work with you in grading the exams. The exams are usually group graded; you might grade problem number one on every exam while someone else does number two, and so on. The marking goes very quickly this way.

The TA should attend all the lectures in order to explain the tricky points to his own section, and answer questions based on the lecture, and to keep in step with the lecturer. Try to present the material from the same point of view as your lecturer. This does not preclude the introduction of alternative devices so long as you are sure they do not undermine a purpose of the lecturer. Never, never present material or make comments which appear to be a criticism of the lecturer or his techniques. To do so is to undermine student morale. Always feel free to discuss troublesome points with your lecturer.

Prepare, don't be caught flat-footed by assigned problems. On the other hand, don't bluff - "I don't know how to work that problem but I will by next meeting" is an appropriate way out. Of course, if this is resorted to too often, it probably means that you are not preparing sufficiently. When you are exploring (i.e. fishing for a technique), tell the students so. This will aid him both in following your work and in his perception of how mathematics is done. Remember, you can't do everything - so don't try. What you do should be done well and completely. Choose examples carefully - not all routine, not all esoteric. Your lecturer will help in this selection at the weekly meetings.

...and all these things shall be added. -- Gospel according to St. Mathew.

RECORD KEEPING

At the beginning of each semester make sure students are properly enrolled in your class. If a student's name is not on your computer roster: check his class schedule; direct him to his proper classroom; be happy. As soon as your class membership has stabilized, establish a well-notated grade book. Careful records should be kept of test scores, homework and quiz grades, attendance, etc. Students who question their final grades are more easily placated by complete records, firmly established criteria, and a general atmosphere of definiteness. (Notations such as ✓, -, etc. are too qualitative to be meaningful.) In lecture-recitation groups, the lecturers may prescribe specific formats for record keeping.

Be sure you can justify your final grades. Retain class records after the course is over. Give all such records to the secretaries when you leave (even for the summer). Grade books are available from the department offices.

It is always good when a man has two irons in the fire.
—Francis Beaumont(1584-1616) *The Faithful Friends.*

BUDGETING TIME

Budgeting time between your various roles - teacher, student, aide - is of vital importance. You should realize from the beginning that as a teaching assistant you are an extremely important link in the educational process. The job is not easy, and the responsibilities are treat. Generally speaking you should regard your responsibilities in three parts: first, to facilitate in every possible way the intellectual development of the individual students in your sections; second, to ascertain and carry out the aims of the faculty coordinator in the development of the course; third, to further your own training and development as a mathematician and teacher. If you neglect any of these areas, you are not fulfilling your responsibility, and aside from the damage done to yourself and others, you could be relieved of your job. The Graduate School and the Department of Mathematics require you to maintain a superior performance record in your own graduate courses in order to continue as a teaching assistant.

The time required for teaching duties varies from person to person. Some will tell you it takes 15 hours a week, others will say 20. The number of hours is less important than doing the job properly and maintaining a balance between teaching and studying.

A half-time teaching assistant should expect to discharge his duties and carry 3 graduate courses. If you find your teaching assistant job more demanding than you feel is fair, speak to the professor in charge, who may be able to suggest ways in which you can do the job just as well with less strain.

YOUR ATTITUDE TOWARD YOUR JOB

1. There is no harm in being friendly. Get to be interested in the students and their progress. Be enthusiastic about the course you are teaching and about mathematics in general.
2. If you don't know an answer, say so, go home, look it up and answer it next time. Don't BS.
3. Don't knock any other instructor in the department in front of your students.
4. Making students feel inferior, usually makes you inferior.
5. Treat all students equally; don't allow favoritism to influence your grading.
6. Students are human, have some trust in them. If they are going to deceive you, they will try more than once. Believe them. If one test score is very different (usually lower) from his other scores, assume the student had a bad day.
7. Insist that your students use mathematical vocabulary. Mathematics is a language. Use it in class.
8. Take interest in your students. If a student misses class regularly, find out why. It takes only a few minutes to make a phone call.
9. Don't be embarrassed by your mistakes; you are only human. If you make an error, correct it even if you have to bring it up in a later class meeting. Analyze your error with the help of your class. Show them what you did wrong. On the other hand, intentional errors have a dubious teaching value.
10. Meet your class at all regularly scheduled times. Be on time and expect the same from your students. In elementary courses, there is always something to do, - further drill, review, etc. Thus dismissing class early is not a good practice, especially in recitation classes.

POLYA'S TEN COMMANDMENTS

1. Be interested in your subject.
2. Know your subject.
3. Know about the ways of learning: The best way to learn anything is to discover it by yourself.
4. Try to read the faces of your students, try to see their expectations and difficulties, put yourself in their place.
5. Give them not only information, but "know-how," attitudes of mind, the habit of methodical work.
6. Let them learn guessing.
7. Let them learn proving.
8. Look out for such features of the problem at hand as may be useful in solving the problems to come - try to disclose the general pattern that lies behind the present concrete situation.
9. Do not give away your whole secret at once - let the students guess before you tell it - let them find out by themselves as much as is feasible.
10. Suggest it, do not force it down their throats.

Le secret d'être ennuyeux c'est de tout dire. - Voltaire.

THE SUPREME TEACHER

All people have different ideas of the traits of an outstanding teacher. Classroom behavior, respect, attitude, and an understanding of the material presented must all be taken into consideration in determining a great teacher from a good one.

An instructor's attitude towards the subject matter he is presenting to the students is one aspect of a distinguished educator. If the teacher dislikes the course he is teaching, his enthusiasm for the subject is nil, and as a result, makes the class dull for the students. A remark like, "I'm just here to answer your questions, not to be a lecturer" gives a student a rather poor image of the teacher. And the harmful part of this type of attitude by the teacher is that he does not help clarify the material the student is expected to read or to hear in lecture. Under these conditions, it is very difficult for a student to have the desire to learn. Many people argue that it is the fault of students that a class is dull because the students do not ask questions to keep the class alive; but because of the students' lack of understanding of the material, they are unable to ask signigicant questions. The teacher could help the students by transforming the hard material into easy, understandable English, which would then make it possible for the student to ask questions. Questions come from understanding; therefore, if a student is taught the basic subject matter, he can comprehend the ideas and ask questions because of this thorough understanding. The result of the instructor's having a positive attitude towards the course and a desire to go out of his way to help the student learn subject matter, is that the student tends to work a little harder, to learn faster, and to get better grades.

Probably the most important trait of an outstanding teacher is the ability to respect the student as the student respects him. It seems that many educators look down on the student and condemn him for being so stupid. But the distinguished educator brings himself to the student's level and thus strengthens the student-teacher relationship. It is this teacher that succeeds in teaching everyone; not just the smart pupils (who can comprehend the material without the teacher's help anyway). Such teachers always seem to gain more respect instead of less respect as many people would think. If a teacher could respect the student as a student respects the teacher, the relationship between them would result in the student's tending to work harder, to learn faster, and to get better grades. (Taken from an essay by an unknown, and therefore anonymous, student.)

Exercise. Enumerate traits (good and bad) of teachers you have had. Is the "supreme teacher", God's right-hand-man? Try to determine what makes the "supreme teacher"

And thick and fast they came at last,
And more, and more, and more.
-- Lewis Carroll, *The Walrus and the Carpenter.*

QUESTIONS OF UNCERTAIN MERIT

1. Use old homework assignments on the final exam.
2. Don't give unannounced quizzes. It promotes attendance.
3. Exhibit an attitude of acceptance toward questions the students ask.
4. Ask frequently if the students have any questions.
5. Call the students by their last names.
6. Require office visits early in the semester before you get swamped with your own studies.
7. Be willing to discuss with your students any mathematical work they are doing in other courses.
8. Inform students of other courses they may wish to take in the department.
9. Have your lecture notes prepared about a week in advance.
10. Cover as much material as you can each class period; don't worry about the syllabus.
11. On occasion send the entire class to the board to do problems.
12. a) Never give make-up exams (average existing grades).
    b) Always give make-up exams, but make them harder.
13. Write more than is necessary on the board.
14. Make a list of knowledge, which if mastered, will guarantee passing in the course.
15. A teacher should appear in class respectably dressed and groomed.
16. Hand-out dittoed copies of interesting and important ideas, explanations of proofs, examples, etc.
17. Read other text books related to your course to compare treatment of the subject.
18. Give text examples on exams.
19. Change presentation each time you teach a course.
20. Speak in a monotone; boredom is contagious.
21. Give questionaire at start of course based on prerequisites. At end of course ask for a student evaluation, not to be read by you until after the grades are in.
22. When handing back exams, ask students who had correct solutions; to put it on the board and explain their solution.
23. Attend department colloquia to learn effective teaching techniques (also see some bad lecturers), to learn some mathematics, to meet new people.
24. Make errors. It keeps students alert.
25. Don't be embarrassed about your mistakes: you are only human. (Even the best of your professors make mistakes.)

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ADAPTED FROM BOWLING GREEN STATE UNIVERSITY

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